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SOME NOTES FOR SIMPLE PAVLOVIAN LEARNING

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SUMMARY: Some neural nets capable of mediating simple Pavlovian reflexes in their qualitative features are represented, along with some suggestions toward further elaboration.

SOME NOTES FOR SIMPLE PAVLOVIAN LEARNING

by A. S. Householder

In the accompanying figures are exhibited some nets representing some of the qualitative features of the simplest types of Pavlovian reflex learning. It is perhaps clear how, by inserting internuncials and adding circuits, the quantitative characteristics can be adjusted. Admittedly a great many such additions might be required before achieving any degree of realism.

Fig. 1 represents the simplest form of conditioning with extinction. Here and hereafter the threshold is 1 or irrelevant unless inserted; and S and S' denote the unconditioned and conditioned stimuli, respectively. In this net the occurrence of $S'(t)\ S(t+1)$ activates the cycle, after which $S'(\tau)$ implies $R(\tau+2)$. However any occurrence of $S'(t) \sim S(t+1)$ inactivates the cycle. Thus a single trial establishes conditioning, but a single failure to reinforce will extinguish it.

Fig. 2 shows one step in the elaboration. Here one trial activiates C_1 but does not yet set up the conditioning; a second trial is required, at which time C_2 is activated and S' (via an internuncial for timing purposes) is made liminal. A single nonreinforcement will inactivate C_2; a second will inactivate also C_1.

If C_1, instead of C_2, were connected to R, then a single trial would establish conditioning, but unstably, in the sense that a single nonreinforcement

would extinguish it. Two consecutive trials would increase the stability, necessitating two consecutive nonreinforcements to extinguish it. This is readily generalized by taking 2 cycles in stages, of which the m-th is connected to R. Then conditioning would be established after m trials, but each further trial increases the stability, up to the number n - m of additional stages.

Fig. 3 represents the first aspect of the delayed reflex, with one-stage conditioning. Note that $S(t)$ always implies $R(t + 1)$. Now the occurrence of $S'(t)\ S(t + 1)$ activates C_1 as in Fig. 1, so that subsequent occurrence of $S'(\tau)$ implies $R(\tau + 2)$. However if $\sim S(\tau + 1)$, then the cycle is inactivated and the conditioning extinguished. Also the occurrence of $S'(t)\ S(t + 2)$ activates C_2 so that subsequent occurrence of $S'(\tau)$ implies $R(\tau + 3)$.

The most interesting feature of the delayed reflex, however, in Pavlov's description is this. Continued reinforcement of the delayed reflex (corresponding to activation of C_2 and subsequent stages) has the effect that the time of occurrence of R moves progressively forward; nonreinforcement first increases the delay before continued nonreinforcement finally extinguishes the conditioning.

To achieve this in its most elementary form, add another stage to C_2 as in Fig. 2, but connect this cycle to I_2 with an inhibitor and to I_1 with an excitor. Then $S'(t)$ is sufficient to produce $R(t + 2)$ if either this new cycle is active, or if C_1 is active, whereas if C_2 alone is active, then $S'(t)$ will produce $R(t + 3)$.

Fig. 4 gives the phenomenon of generalization. It is supposed that S_1' and S_2' are affected by different degrees of intensity, or different qualities of the same type of stimulus (e.g., distinct tones). Either conjunction $S_1'(t)\ S(t + 1)$ or $S_2'(t)\ S(t + 1)$ is sufficient to activate both cycles C_1 and C_2, after which the occurrence of either $S_1'(\tau)$ or of

$S'_2(\tau)$ is sufficient for $R(\tau + 2)$. However, the non-reinforced presentation of S'_1 above, that is to say $S'_1(\tau) \sim S(\tau + 1)$, inactivates C_1, but not C_2.

A more realistic representation requires obviously more than two degrees or qualities, but should have also the following features: Suppose the afferents are $S'_1, \ldots, S'_2$, in the order of degrees of intensity or of a simple ordering of the qualities. Progressive reinforcements of a particular S'_α should establish $S'_{\underline{\alpha}}$ sooner than other S'_β and for establishing S'_β by reinforcing S'_α, the required number of reinforcements should increase with $(\beta - a)$. Conversely, in the subsequent extinction of a given S'_β, more non-reinforcements should be required for small $(\beta - \alpha)$ than for large. Again, as extinction proceeds by non-reinforcement of S'_β, extinction of any S'_γ should proceed at about the same relative rate when β lies between γ and α; whereas when γ lies between β and α the rate at which S'_γ is extinguished should depend upon the relative values of $(\beta - \gamma)$ and $(\gamma - \alpha)$.

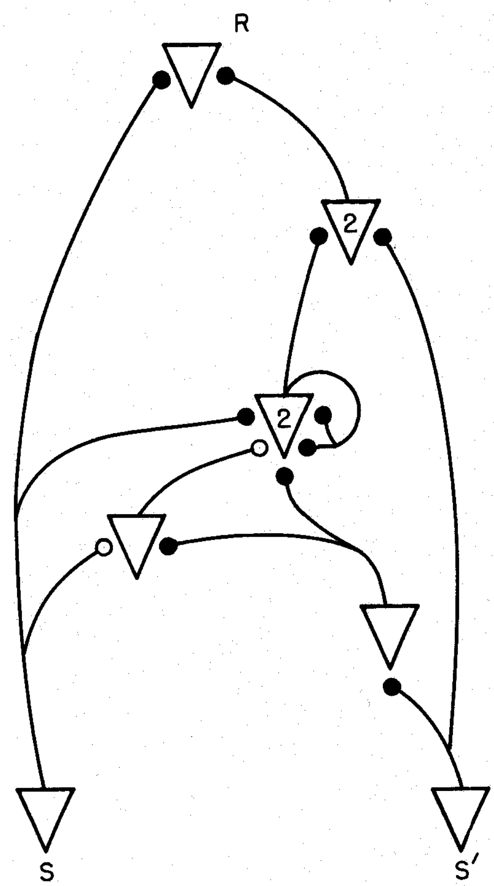

Fig. 1— Simple conditioning

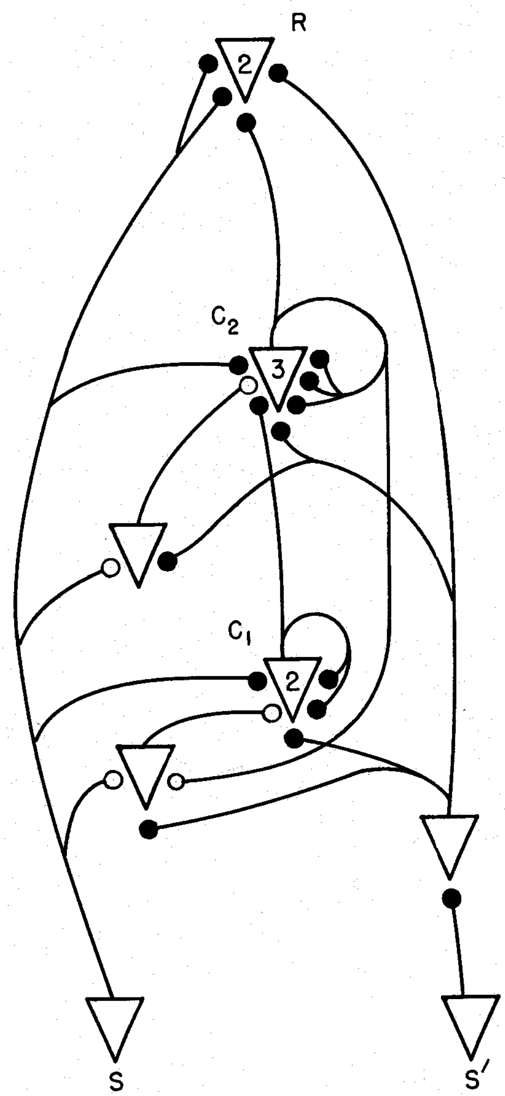

Fig. 2 — Two-stage conditioning

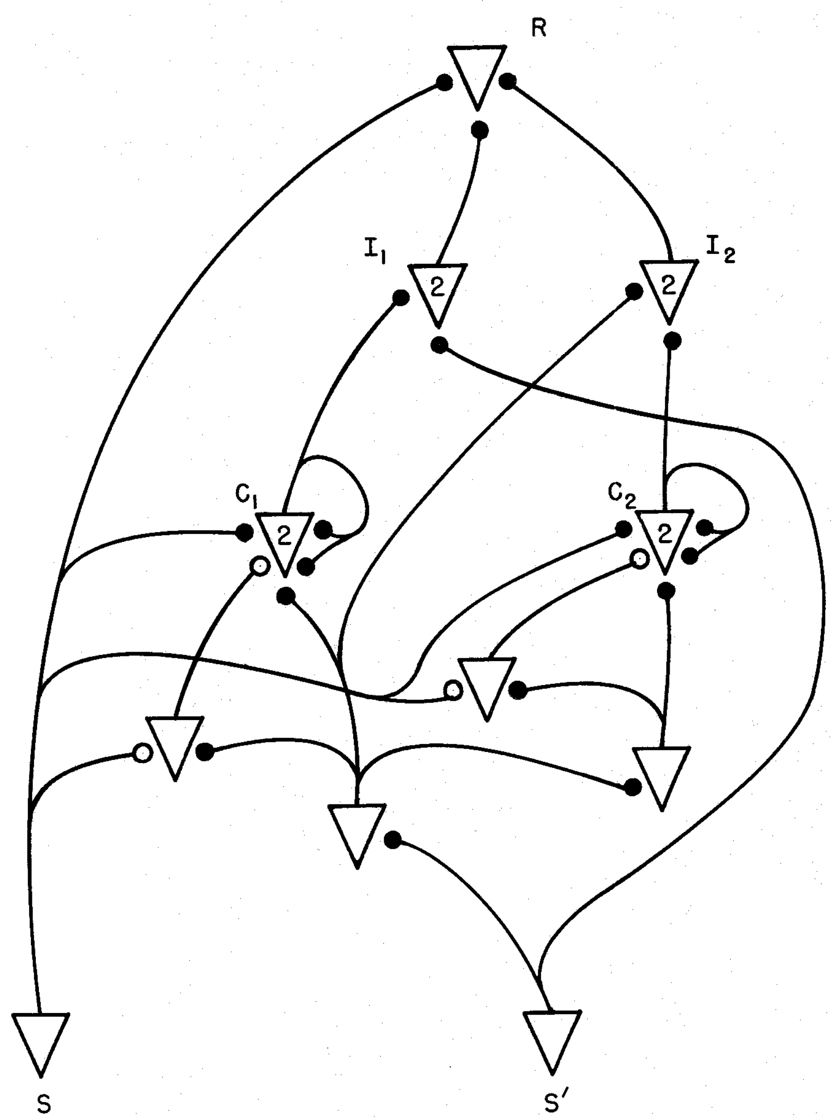

Fig. 3 — Simple delayed reflex

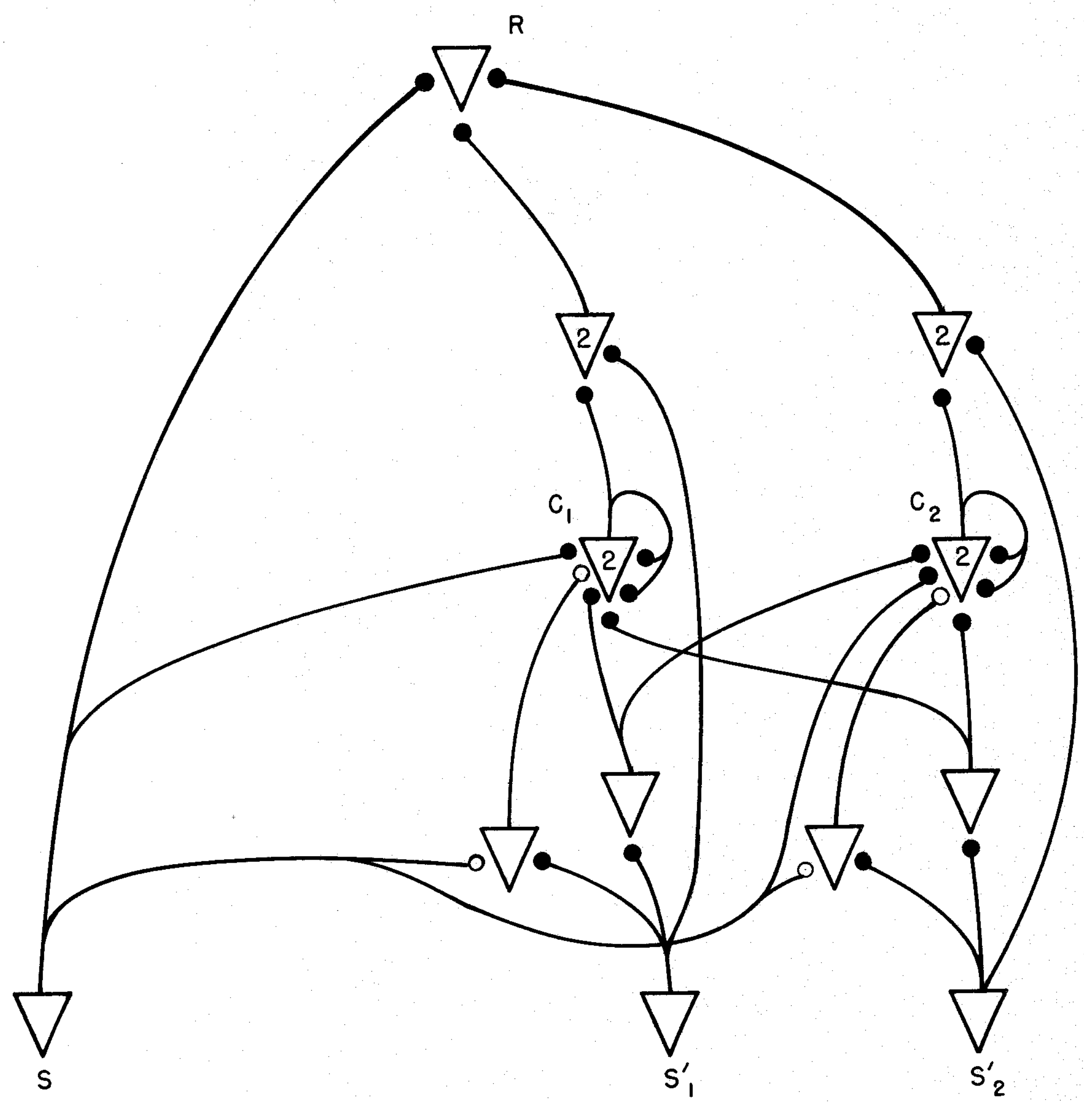

Fig. 4 — Generalization